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ABSTRACT

The verbal interaction and problem-solving behavior of groups of high and average ability learners were compared during computer-assisted cooperative problem-solving to determine the problem-solving behaviors that relate to success within this context. Thirty-six fourth grade students were assigned to groups of three to form 12 groups, six of high and six of average academic ability. All groups were given the task of using Logo Turtlegraphics to reproduce a given line design on the computer screen. Results of the task were evaluated using four predictors of problem-solving success: (1) asking more task-related questions; (2) using a greater variety of problem-solving strategies; (3) spending more time on strategy; and (4) showing higher levels of strategy elaboration. It was found that high ability groups invested more time in strategy planning, used a greater variety of strategies and a greater number of long task statements, reached higher levels of strategy elaboration, and engaged in more social talk. The additional time that successful groups spent on problem-solving strategies was related to their use of longer task statements, questioning, and variety of problem-solving strategies. These findings suggest that teachers might try to foster the kinds of verbal interaction and problem-solving behaviors that appear to promote success in group computer learning, and that software should be designed in such a way as to stimulate group members to interact by asking questions of each other which may in turn promote the problem-solving process. A table depicting the means for a series of 2 (ability) by 2 (success) analyses of variance on each of the verbal interaction and strategy use variables is appended. (28 references) (CGD)

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Verbal Interaction in Computer-Assisted Cooperative Problem-Solving Groups

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Paper presented at the AERA annual meeting, New Orleans, April, 1988.

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ABSTRACT

Groups of high and average ability learners were compared on verbal interaction and problem-solving behavior during computer-assisted cooperative problem-solving. The purpose of the study was to identify problem-solving behaviors which relate to success within this context. Thirty-six fourth grade students were assigned to groups of three to form twelve groups, six of high and six of average academic ability. All groups were given the task of using Logo turtlegraphics to reproduce a given line design on the computer screen. Predictors of problem-solving success included: asking more task-related questions, using greater variety of problem-solving strategies, spending more time on strategy, and showing higher levels of strategy elaboration. High ability groups spent more time on strategy, used a greater variety of strategies, used a greater number of long task statements, reached higher levels of strategy elaboration, and engaged in more social talk. Time that groups spent on problem-solving strategies was related to their use of longer task statements, questioning, and variety of problem-solving strategies. Educational implications, including those for the development of computer-assisted learning materials for use with problem-solving groups, are also discussed.

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Verbal Interaction in Computer-Assisted Cooperative Problem-Solving Groups

In many elementary schools with limited access to microcomputers, students frequently work on computer assignments in groups rather than individually. In fact, a recent national survey of schools found that teachers assigned students to groups for their computer work 46% of the time [1]. Although this practice is usually pragmatically determined, it has apparently not had adverse effects on student achievement. Students working in computer-assisted learning (CAL) groups have been found to achieve as well or better than those working independently in a variety of subject areas [e.g., 2, 3, 4].

There are several theoretical perspectives which suggest that the peer interaction that occurs in these computer groups may be beneficial to learning. These perspectives include Vygotsky's [5] and Piaget's [6] emphasis on the social construction of knowledge (further delineated by Bearison [7]), on the one hand and to peer modeling as proposed by Bandura [8] on the other hand. From the social cognitive point of view, when students interact with their peers, they are faced with ideas, explanations and information that are inconsistent with, or which contradict, their prior knowledge and beliefs. They are asked questions which force them to abandon their own perspective and take the point of view of others. Confronting these inconsistencies and contradictions challenges learners' current point of view, and resolving such cognitive conflicts results in cognitive restructuring [7]. For example, when students receive new information from peers during group work, they presumably add detail to

their existing cognitive schemas, explore and correct their misunderstandings, fill in gaps in their knowledge, and/or reorganize their knowledge structures [5,6,7]. During peer interaction, students are exposed to new strategies, terminology, and ways of thinking about problems; these experiences can restructure their own thinking, which may in turn affect their problem-solving behavior. From the social modeling perspective, peer interaction provides opportunities for imitation of successful problem-solving behaviors. Both of these theoretical perspectives can explain changes in students' levels of competence as a result of peer interaction in small groups.

A question which arises is which interactions promote success in these computer learning groups? According to Webb [9,10] very little is actually known about the relationship between peer interaction and learning in non-computer groups and even less is known about this relationship in computer groups. There is a small body of research on peer interaction and learning in computer-assisted learning groups. Most of these studies have examined the effects of computer programming (particularly Logo) on variables such as cooperative behavior [11,12], problem-solving success [11], types of strategies used [13,14], metacognitive behavior [11], and verbal interaction [9,12,13]. Additional research is required to determine what kinds of peer interaction are beneficial to learning in non-programming contexts. The focus of the present study was on verbal interaction and strategy use in small groups working on a general (non-programming) problem at the computer.

Peer interaction and problem solving success in computer learning. A few studies have shown a positive relationship between certain verbal interaction variables and problem-solving success in computer learning

groups. For example, Johnson, Johnson, and Stanne [15] found that cooperative CAL groups engaged in more task talk and less social talk than competitive and independent groups and such cooperative groups were more successful in solving the problems. Webb and her colleagues [10,13] have also found a positive relationship between verbal interaction and problem-solving success. In a study of predictors of computer programming outcomes, Webb [10,13] found that certain group verbal interaction variables such as giving and receiving explanations, receiving responses to questions, and verbalizing input aloud while working at the keyboard, predicted programming success. The type of verbal interaction Webb has most often found to be associated with success in small groups learning computer programming is the giving of explanations. However, similar studies by Webb [9] and others using Logo programming have not supported these findings [e.g.,9,16].

Several researchers have found that computers can be used to enhance students' general problem-solving *success* [e.g.,17,18,19]. However, as Clements and Nastasi [11] have pointed out, most of these studies have focused on outcomes and have not examined the problem-solving *process* which contributed to such success. Only a few researchers have identified specific strategies which emerge during small group computer problem-solving. For example, Bradley [14] found that a "top-down" approach to problem-solving with Logo programming was positively related to success. In an investigation of problem-solving strategies used in computer programming, Webb identified several planning and debugging strategies which were related to programming achievement [3]. However, these strategies are specific to computer programming and may not apply to more general problem-solving tasks.

The present study was designed to explore the verbal interaction and problem-solving behaviors occurring within small learning groups working cooperatively on a computer-assisted general problem-solving task. The purposes of the study were: to identify specific behaviors which promote success in this context, to determine whether any of these behaviors vary for groups of different academic abilities, and to identify any patterns of verbal interaction and strategy use which may affect learning. Determining specific problem-solving behaviors which predict success might help to set the stage for designing instruction and developing materials to be used for group work in problem solving with computers. In the present study high and average academic ability groups were compared. Ability was selected as a variable of interest because high ability subjects tend to do well on complex cognitive tasks; and it was expected that an examination of their interaction patterns and strategy use, and how these behaviors differ from those of average ability subjects, might help to provide the basis for designing materials for training average and low ability students in successful CAL group problem-solving processes. In reviewing the use of problem-solving by high ability subjects in noncomputer settings, Feldhuson and Treffinger [20] have noted differences between ability levels in amount of verbal interaction. Therefore, it might be expected that differences in verbal interaction would be found between computer problem-solving groups of high academic ability and those of average ability. It might also be expected that the high ability CAL groups would use identifiable strategies more frequently than would average groups. Such differences have been observed between high and average ability subjects in noncomputer contexts [20].

METHOD

Overview

This study involved subjects working in groups of three to solve a figural-spatial problem at the computer. Think-aloud protocols [21] were taken on the problem-solving interaction of all groups. Protocols were transcribed and verbal comments were coded into seven categories. Problem-solving strategies were identified and strategy use was coded into four categories.

Sample

Thirty-six fourth-grade students between the ages of nine and 10 participated in the study. Eighteen high ability and 18 average ability subjects were randomly selected from classrooms in one middle-class school in Southern California. High ability subjects were those identified as being academically gifted by their scores on the Wechsler Intelligence Test for Children-Revised (WISC-R). Teacher judgment was used to identify students qualified for the average group. An equal number of males and females were selected from both ability levels. Subjects were then randomly assigned to groups of three so as to form six high ability and six average ability groups. It had previously been determined that all subjects were experienced with computers, but none had engaged in Logo activities.

Procedure

The process of think-aloud problem-solving was modeled for the subjects before the experiment began by having all subjects view a three-minute videotape which showed pairs of people verbalizing their thoughts

while working cooperatively on a problem at the computer [1]. The videotape models asked questions of each other, gave information, explained reasons for their actions, and made suggestions as appropriate to the task. Subjects were told that they too would be working together in groups on a computer to solve another type of problem. The importance of working cooperatively to solve the problem was also stressed.

Groups were stationed at computers in two adjoining computer labs where they were familiarized with a single key version of Logo turtle graphics which they would later use to solve the problem [22]. With this system, subjects press predetermined keys to advance the graphics cursor one space at a time or to change direction according to instructions which can be displayed on request. It must be stressed that turtle graphics does not require the use of programming; this approach was used so as not to confound problem-solving with programming skill.

The line design in Figure 1 was shown to all groups for 30 seconds and then removed from view. Subjects were given the problem of working together cooperatively in their groups to reproduce the same design on the computer screen. This particular task was selected for several reasons. First of all, subjects know when they have succeeded because it is a convergent "one right answer" problem. In pilot work with high and average ability fourth grade students at a different school, it was found that the problem could be solved by subjects of this age, that it was challenging and maintained their motivation, and that the task elicited a variety of problem-solving strategies. In addition, the figural-spatial characteristics

[1] The "Towers of Hanoi" problem was used for the modeling videotape. This problem was selected for presentation because the task characteristics and task demands are spatial-figural, as they are in the problem posed for the subjects; and it was expected that the cognitive process behaviors modeled on video would more closely parallel those of the task at hand.

of this task make it somewhat representative of tasks posed in problem solving software in frequent use in elementary classrooms.

Insert Figure 1 about here

Groups were instructed to think aloud as they performed the task so that their actions and their reasons for actions could be tape-recorded. Recorders were turned off after 20 minutes or as soon as the problem was solved, whichever occurred first. In the pilot work 20 minutes was determined to be an optimum length of time.

Coding of Verbal Interaction

A modification of Bales' [23] Interaction Process Analysis coding scheme was used to develop an observation checklist containing seven verbal interaction categories (summarized in Table 1). Tapes were analyzed for three main types of verbal interaction: task, social, and maintenance. Task interactions were coded as either statements or questions. Task questions included asking for information, suggestions, directions, explanations, opinions or evaluations. Statements included giving information, suggestions, directions, explanations, opinions or evaluations, and describing what was occurring on screen. Task statements were further coded as short (one or two words) or long (more than 3 words). Short task statements frequently involved calling out directions (e.g. "Go left.") without any stated reason or explanation, or making evaluative exclamations (e.g., "Great!"). The majority of task statements were short. Longer task statements occurred less frequently and often consisted of complete phrases or sentences. Such longer statements tended to contain some kind of elaboration, explanation, rationale, or plans (e.g., "We got to

get an angle to connect the lines."). Maintenance interactions included subjects' encouragement of each other and their comments regarding group organizational matters such as taking turns. Positive social interaction included all social and personal comments unrelated to task or maintenance. Negative social interactions included comments of antagonism and discouragement. An additional category was established for competitive comments; however, only one group interacted in this manner and so the category was dropped from data analysis.

Insert Table 1 about here

Verbal interactions were classified into the seven categories and were coded in terms of their frequency of occurrence. The interaction was coded by two independent coders with an average inter-coder reliability on the 12 groups of .96.

The length of time required to complete the task varied across groups; therefore, for all verbal interactions, frequencies of observed behavior were divided by elapsed time for each group. In this way frequencies were converted into interaction rates. Table 1 displays the mean interaction rates for each of the verbal interactions as well as their percentage of the total interaction.

Coding of Strategy Use

A central purpose of this study was to document the problem-solving behaviors related to strategy use which were observed in the cooperative learning groups as they worked to solve the problem. Although the strategies themselves were only of minor interest (since the type of

strategy used to solve a problem varies with task characteristics and task demands), it was necessary to identify a set of strategies in order to determine frequency and variety of strategy use and level of strategy elaboration. Therefore the verbal interaction transcripts were analyzed to determine the type, frequency, and variety of problem-solving strategies used by different groups.

Many different systems have been used to categorize problem-solving strategies [e.g., 21,23,25]. Based upon this literature, a classification system was designed which included strategies commonly used in solving convergent problems such as the computer task posed in this study. Of the 10 strategies selected, only six were actually used by groups in this investigation. These strategies are presented below with examples.

Goals and Subgoals: This is a "working backwards" strategy and involves breaking the problem up into component parts, solving each of the parts, and then combining them into a solution of the whole problem. For example, in reducing the fraction 16/18, listing the factors of 16 and 18 might be a subgoal [26]. Several groups in the study noticed that the design could be seen as being composed of two identical triangles superimposed with one "turned upside down", and that they had to figure out how to make one triangle, then make another the same size but in reverse and superimposed onto the first one.

Means-Ends Analysis: This is a general problem-solving strategy. It involves a *linear* "working forwards" approach to the problem, focusing on what-leads-to-what and cause-effect [26]. One group displayed means-ends analysis in the following interaction: "I'll see how many times we push the button for one line, and then we'll push the button that many times to make the other lines." "Then it will be straight."

Classification. In this strategy attributes of the problem or object are identified so that the unfamiliar can be classified as something familiar or known [25]. For example, several groups classified the design as a star with six identical points.

Concrete coding. Anderson [25] described concrete coding as representing the problem in some concrete manner such as making a model, drawing a diagram or graph, or translating the problem into actions, pictures or analogies. For example, several groups talked about drawing the design on paper.

Abstract coding. This strategy involves restating the problem in abstract code such as verbal or mathematical symbols, for example, writing the problem out in words or an equation [25]. One group suggested that the steps to follow should be written down on paper.

Hillclimbing. This strategy is related to *Means-Ends Analysis*. In hillclimbing, the current state of the problem is analyzed and compared to the end result desired in order to determine the action or direction to take next. This is comparable to climbing a hill in the fog by first climbing to a spot that can be seen, stopping to reconnoiter, then climbing to the next visible point, and so on [25]. This strategy includes analysis of mistakes made; for example, one group, after making a design, said: "This is a five-point star, it's wrong." "We need a six point.".

Identified strategies were coded as to type of strategy using this classification scheme. In addition, each use of a strategy was also rated as low, medium or high in terms of its level of elaboration and was assigned a score of one, two, or three respectively. This approach yielded a strategy elaboration score for each of the 12 groups. Strategy elaboration refers to the depth to which a strategy is explored. Elaboration does not refer to the

length of time spent on a strategy; time on strategy could be used to dabble with the strategy superficially, or it could be used to exploit the full potential of that strategy for the task at hand. Indicators of strategy elaboration include: the degree of subjects' awareness that a plan or strategy is being used; the extent of verbal articulation of a plan, rationale, goal, subgoals, or specific steps in a procedure; and/or the degree to which the strategy is persistently employed while it still has potential for problem solution. A few groups in this study showed little evidence of any use of problem-solving strategies except for what appeared to be random trial and error. Trial and error (unless it was systematic) was not considered to be a strategy. In all groups, a great deal of the verbal interaction consisted of calling out directions, e.g., "Go right", "More, more.", "Now down." without any verbalized explanation, reason, or plan. In other cases, strategies were articulated in varying degrees of clarity and elaboration. Finally, total amount of time spent on problem-solving strategies was also measured for each of the 12 groups. Strategy classification, level of strategy elaboration, and measurement of time on strategy were determined by two coders independently. The two coders met to reconcile any disagreements and the reconciled data were used in the statistical analyses that follow.

RESULTS

A series of 2 (ability) x 2 (success) analyses of variance were used to analyze data on each of the verbal interaction and strategy use variables. Table 1 displays means for this data. Both rates and percentages of the total interaction (in parentheses) are shown for all verbal interactions.

Rates based on the time actually spent on strategy are presented for the strategy use variables.

Seven of the 12 groups solved the problem successfully. Five of the six high ability groups were successful compared to two of the six average groups. These high ability groups did somewhat better on this task than did average ability groups. However, the association between ability and success was not significant according to Fisher's Exact Test ($p = .11$).

Time for groups to complete the task ranged from 9 to 20 minutes. A two-way ANOVA on the data for completion time showed no main effects for success, $F<1$, or ability, $F(1,8)=3.74$, $p>.10$, and no significant interaction between success and ability.

Verbal Interaction Variables. As Table 1 indicates, for task questioning, significant main effects were found for success but not for ability or for the interaction between ability and success. Successful groups showed a higher rate of questions per minute, $F(1,8)=7.67$, $p<.05$, and their questioning comprised a greater percentage of their total verbal interaction, $F(1,8)=11.14$, $p< .01$, than was true for unsuccessful groups.

On the other hand, significant main effects were found for ability on two of the verbal interaction variables: long task statements and short task statements. High ability groups made more long task statements per minute than did average groups, $F(1,8)=17.03$, $p<.01$, and these statements comprised a greater percentage of the total verbal interaction for high ability groups than they did for average ones, $F(1,8)=21.09$, $p<.01$. No significant effects were found for success or ability x success on this variable. High ability groups made fewer short task statements than did average ability groups. This difference was marginally significant for rate per minute, $F(1,8)=4.94$, $p=.05$, and highly significant for percentage of

total verbal interaction, $F(1,8)=32.15$, $p< .001$. Once again no main effects for success or for the ability x success interaction were found on this variable.

No main effects or interaction effects were found for any of the other verbal interaction categories.

Strategy Use Variables. The two-way ANOVAs on the strategy use variables revealed significant effects for success for both proportion of time on strategy and strategy elaboration score. The proportion of total time that successful groups spent on strategy was significantly greater than that of unsuccessful groups, $F(1,8)=15.35$, $p<.01$, as was their strategy elaboration score, $F(1,8)=12.92$, $p<.01$. No main effects for ability and no interaction effects were found for these two variables. No significant effects were found for frequency and variety of strategy use.

A total of 27 instances of strategy use were identified. Fifteen of these strategies occurred at the low level of elaboration, nine at the medium level, and three at high. Certain of the strategies were used more frequently than others. Specifically, of the 27 cases of strategy use, eight were instances of the goals and subgoals strategy, six exemplified concrete coding, and six were classification strategies. Most instances of strategy use (56%) occurred at a low level of elaboration, with 33% at a medium level, and 11% at a high level. Goals and sub-goals strategies were used only by successful groups; however, not all successful groups used this strategy, suggesting that there was more than one strategy that could be used to solve this problem.

Patterns of Interaction. Correlations between certain areas of verbal interaction and strategy use were also examined. First, task questioning was significantly related to time on strategy, $r = .75$, $p < .01$, frequency and

variety of strategies used, r =.53, p <.05 & r =.52, p <.05, and to elaboration score, r=.64, p<.05; these findings suggest that strategy use might be fostered by questioning behavior. In addition, time on strategy proved to be significantly related to use of long task statements, r =.62, p <.05, to elaboration score, r =.66, p <.05, and to frequency and variety of problem-solving strategies, r=.78, p <.01, & r =.77, p <.01, respectively.

Summary of Findings

Success. Successful groups asked more task-related questions, remained longer on their problem-solving strategies, and reached higher levels of strategy elaboration than did unsuccessful groups.

Ability. High ability groups made more long task statements and fewer short task statements than did average groups.

Patterns of interaction. Two patterns of interaction were suggested by correlations among variables: 1. task questioning was related to time on strategy, strategy frequency and elaboration. Time on strategy was related to use of long task statements, and frequency, variety, and elaboration of strategies.

DISCUSSION

Success.

As predicted, there were significant differences in problem-solving behaviors between successful and unsuccessful groups. The most important of these differences is that successful groups asked significantly more task questions than unsuccessful groups. This suggests that asking task-related questions in and of itself may promote success in the group CAL context. This finding is clearly consistent with theories of the social construction of knowledge [5,7]. For example, the very act of formulating a question about the problem or problem solution path might help the learner to clarify

the meaning of problem concepts and relationships among concepts. That is, such questioning might be a form of thinking out loud; which, in a peer context, could not only help the questioner clarify concepts, but could also provide clarification and meaning for other members of the peer group. In addition, asking task-related questions is a way of actively soliciting information and explanations--the very input needed for the construction of knowledge and meaning. If explanations and information are received (and they are more likely to be received when asked for than when not), this input may fill in gaps in prior knowledge, clear up misconceptions, and generally resolve cognitive inconsistencies and contradictions for the questioner. According to Bearison [7], resolving such cognitive conflicts should create some change in the learner's cognitive structures or processes. The aggregate of these changes in group members' cognitions may promote the group's success in solving the problem. While these explanations fit cognitive theory, they have not yet been empirically tested. The purpose of this study was to determine *what* peer interactions affect success in problem-solving, and here it is clear that questions do make a difference; the question of *how* peer interaction influences learning has yet to be empirically explored.

Successful groups also spent more time on strategy and obtained higher elaboration scores than did unsuccessful groups. These findings could mean that successful groups are simply more adept at elaborating more fully the strategies they use which in turn may account for their success; or on the other hand it could mean that they are successful because they remain on strategy long enough to elaborate that strategy well.

Ability

Ability groups differed on only two verbal interaction variables. Although the amount of task talk in general did not differ for ability levels, high ability groups did use significantly more long task statements and fewer short task statements than did average groups. This difference may be due simply to the more verbal nature of students who function at a higher cognitive level.

Although it was expected that high academic ability groups would be more verbal than would average ability groups, the total amount of verbalization did not differ between ability levels. This finding is inconsistent with results from noncomputer studies involving gifted students [20], and may possibly be due to the characteristics of this particular task or may be attributed to the medium of instruction, computers. In studies which have examined group interaction variables in both face-to-face noncomputer settings and computer-mediated contexts in which participants communicated via computer (but could not see each other), several researchers have reported unexpected group interaction patterns which they attribute to the medium of interaction, that is, computers [27]. It is unclear what role subjects' non-verbal communication may have played in these contexts, or in the present study where at least some of subjects' non-verbal behavior was accessible to their peers. In these groups non-verbal behaviors such as pointing to the screen and keyboard entry may have substituted for verbalizing and may have done so to a greater extent for the high ability groups. In the present study it may be that the high ability (usually more verbal) subjects did not have to rely heavily on verbal communication because the visual communication allowed by the computer medium (and demanded by the visual nature of the task) made a relatively complete statement, requiring little verbal explanation,

description or elaboration; and, in fact, the completeness of the image may have left little room for discussion of alternative interpretations, thus reducing the opportunity or need for further comment.

Patterns of Interaction

Since significant correlations were found among all four of the strategy use variables, discussion of the patterns of peer interaction will center on relationships between verbal interaction variables and strategy use variables. The correlation found between task questioning and all of the strategy use variables may suggest that if students can be encouraged to ask task-related questions this may promote strategy use which may in turn lead to problem-solving success. The relationship between use of long task statements and proportion of time spent on strategy suggests that getting students to speak in phrases and sentences may lead to groups spending more time on strategy which in turn may promote success. However, the strength of the causal role of these variables needs to be further established.

Findings of this study are not restricted to this particular task but may be generalized to similar figural-spatial tasks which elementary school students encounter during CAL problem-solving.

Instructional Implications

Results of this study can be useful in educational planning. One implication is that teachers might try to foster the kinds of verbal interaction and problem-solving behaviors which appear to promote success in group computer learning. This could be accomplished by teachers (or peers) modeling these kinds of peer interaction. For example, it may be helpful to demonstrate and coach students in procedures of asking task-related questions. Alternatively, direct instruction could be used; small

learning groups working at the computer could be trained in questioning skills to be applied during general problem solving at the computer. Future research is needed to determine the types of questions or patterns of questioning which are most effective in this context. Current research is underway to examine the relative effectiveness of several peer-questioning procedures in CAL problem-solving contexts [28].

Time on strategy might be similarly encouraged by direct instruction and coaching. Teachers could instruct students in a number of different problem-solving strategies, then, during problem-solving practice, students could be coached in applying different strategies from their repertoire. Since three of the identified problem-solving strategies were used more frequently by successful groups it may be beneficial to train students in these specific strategies before engaging in similar problem-solving tasks.

Findings from this study also have implications for the development of computer learning materials for use with small groups. Software can be designed in such a way as to stimulate group members to interact by asking questions of each other which may in turn promote problem-solving success. Strategy elaboration behaviors, such as articulating a strategy clearly and explaining reasoning, could also be encouraged in this way. Computer learning materials might be developed for the direct instruction of groups in these strategy elaboration behaviors.

It must be stressed that all of the findings reported here are based on the use of this specific problem task. This figural-spatial problem is representative of some of the types of tasks used in CAL software in classroom use at the elementary level; nevertheless, further research needs to be undertaken using a variety of other problems including divergent tasks and verbal reasoning problems.

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Table 1
Means for Problem Solving Behaviors

	Ability		Task Success	
	High	Average	Successful	Unsuccessful
VERBAL INTERACTION				
Task				
Long Statements				
per minute	8.77	3.55**	7.39	4.45
% of total interaction	(46)	(22)**	(40)	(26)
Short Statements				
per minute	6.57	10.70	7.36	10.41
% of total interaction	(34)	(66) ***	(42)	(61)
Questions				
per minute	1.01	.73	1.10	.54*
% of total interaction	(5)	(4)	(6)	(3) **
Total				
per minute	16.36	15.08	15.91	15.45
% of total interaction	(86)	(94)	(88)	(92)
Social				
Positive				
per minute	2.21	.19	1.64	.63
% of total interaction	(12)	(1)	(9)	(4)
Negative				
per minute	.13	.39	.15	.41
% of total interaction	(1)	(2)	(1)	(2)
Maintenance				
per minute	.33	.35	.36	.31
% of total interaction	(2)	(2)	(2)	(2)
Total Verbal Interaction	19.09	16.02	18.09	16.81
STRATEGY USE				
Time on Strategy (Proportion of total time)	.50	.19	.53	.09**
Frequency of strategy use				
per minute	.22	.08	.20	.07
per minute on strategy	.37	.35	.40	.32
Variety of strategies				
per minute	.21	.08	.19	.07
per minute on strategy	.36	.36	.39	.32
Strategy elaboration score				
per minute on strategy	1.38	1.15	1.79	.52**

* p<.05 Asterisks indicate adjacent pairs of means which are significant
** p<.01
***p<.001

Figure Caption

Figure 1. Stimulus design.